19th Portuguese Conference on Pattern Recognition

Instituto Superior Técnico, Lisboa
November 1st, 2013
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Invited Talk

Physiological Computing: a PR Perspective
Prof. Ana L. N. Fred
Department of Electrical and Computer Engineering, Instituto Superior Técnico, Lisbon and Instituto de Telecomunicações (IT), Lisbon.

Abstract:

In a sentence, physiological computing (PC) deals with the study and development of interactive systems that sense and react to the human body. The most basic sort of PC simply records a signal, such as a heartbeat, and displays it on a screen. More complex systems work on a basis of a bio-cybernetic loop, the main purpose of this loop being to translate patterns of physiological activity into meaningful interaction. From emotional status to identity assessment, this talk addresses the exploration of electrophysiological data in the context of intelligent human-computer interaction. Electrocardiographic signals and electro-dermal responses, acquired in a pervasive manner at the hands level, are shown to be two complementary modalities in the emotion / identity dual assessment goal. The role of pattern recognition in the development of such systems is discussed. Finally, BITalino, a versatile and low cost biosignal acquisition system is presented as a promising tool for pervasive biosignal monitoring and physiological computation.

Speaker Biography:

Ana Fred received the M.S. and Ph.D. degrees in Electrical and Computer Engineering, in 1989 and 1994, respectively, both from Instituto Superior Técnico (IST), Technical University of Lisbon, Portugal. She is a Faculty Member of IST since 1986, where she is currently a professor with the Department of Electrical and Computer Engineering. She is a researcher at the Pattern and Image Analysis Group of the Instituto de Telecomunicações. Her main research areas are on pattern recognition, both structural and statistical approaches, with application to data mining, learning systems, behavioral biometrics, and biomedical applications. She has done pioneering work on clustering, namely on cluster ensemble approaches. Recent work on biosensors hardware (including BITalino – www.bitalino.com) and ECG-based biometrics (Vitalidi project) have been object of several national and international awards, as well as wide dissemination on international media, constituting a success story of knowledge transfer from research to market. She has published over 160 papers in international refereed conferences, peer reviewed journals, and book chapters. She received the “Best paper award in Pattern Recognition and Basic Technologies”, awarded by the IAPR, for the paper “Learning pairwise similarity for data clustering”. She is the editor of over 40 books with the proceedings of international workshops that she organized or co-chaired, including S+SSPR 2004 (Lisbon), S+SSPR 2006 (Hong Kong), ICAART, KDIR and BISTEC and editor of 12 Springer books of selected papers.
Poster Session 1 (10h15 to 11h00)

1 **Staffline Detection in Grayscale Domain**
Ana Rebeiro and Jaime Cardoso
2 **Cancer cell tracking using a Kalman filter**
Tiago Esteves, Maria Oliveira and Pedro Quelhas
3 **Automatic images spectral unmixing of Leishmania infection macrophage cell culture for improved infection indexes accessing**
Pedro Leal and Pedro Quelhas
4 **Mass detection on mammogram images: A first assessment of deep learning techniques**
Inês Domingues and Jaime Cardoso
5 **An Automatic Method for Assessing Retinal Vessel Width Changes**
Behdad Dashthozorg, A. M. Mendonça and A. Campilho
6 **Learning from uneven video streams in a multi-camera scenario**
Samaneh Khoshrou, Jaime S. Cardoso and Luís F. Teixeira
7 **Land and water segmentation of SAR images using textons**
Francisco Seixas, Margarida Silveira and Sandra Heleno
8 **Quality measures for iris images in mobile applications**
Ana Sequeira, Juliano Murari and Jaime S. Cardoso
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Francisco Freitas, Rodrigo Ventura and Miguel Barão
10 **Large Scale Automatic Detection of Sub-km Craters Using Texture Information**
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12 **3D Texture Analysis using Local Binary Patterns**
Pedro M. Morgado, Margarida Silveira and Jorge S. Marques
13 **3D Breast Parametric Model for Surgery Planning - a Technical Review**
Hooshiar Zolfagharzamab, Jaime S. Cardoso and Helérd P. Oliveira
14 **Total Variation Denoising using a Recursive and Spatially Adaptive Filter**
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16 **Clustering 802.11 Wireless Access Points Using Mixture of Hidden Markov Models**
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17 **Towards efficient path planning of a mobile robot in rough terrain**
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18 **Assessment of reliability of cerebrovascular reactivity measurements using breath-holding fMRI**
Joana Pinto, Inês Sousa, Pedro Vilela and Patricia Figueiredo
19 **A Critical Analysis about a Motion-based Approach to Extract Global Trajectories**
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20 **Ground-plane based indoor mobile robot localization using RGB-D sensor**
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7 **Colour Invariant Features for Narrow-Band Imaging in Gastroenterological Examinations**
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8 **Insights into primates genomic evolution using a compression distance**
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João Costa, Tiago Coito, João Caldas Pinto and José Azinheira

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Ana Rita Costa Tedim, Pedro Amorim and Ana Castro

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Paulo Salgado and Paulo Afonso

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Comparative study of two movement identification strategies on BCI motor task
Mariana Branco, João Sanches and Rodrigo Ventura

EEG time-frequency analysis for ERD/ERS temporal pattern characterization on brain computer interface motor task
Mariana Branco, Fernando Lopes Da Silva and João Sanches

Heart Sound Analysis for Cardiac Pathology Identification: Detection of Systolic Murmurs
João Pedroso, Ana Castro and Tiago T. V. Vinhoza

Knowledge on Heart Condition of Children based on Demographic and Physiological Features
Pedro Ferreira, Tiago Vinhoza, Ana Castro, Felipe Mourato, Thiago Tavares, Sandra Mattos, Inês Dutra and Miguel Coimbra

Mobile framework for recognition of musical characters
Rui Silva, Jaime Cardoso and Ana Rebelo

SignalBIT Framework: Principles and Applications
Ana Priscila Alves, Hugo Silva, Andre Lourenço and Ana Fred

Correction of Geometrical Distortions in Bands of Chromatography Images
Bruno Moreira, António Sousa, Ana Maria Mendonça and Aurélio Campilho

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Abstract
In order to improve the players’ and teams’ performances in sports, the technical staffs are now using an ever increasing number of technologies. In this paper we present a study based on a video tracking of players and ball, that can return heat, passes and ball losses maps, which can be a good resource to measure a player/team performance and a base to their improvement.

1 Introduction
Paper support maintains until our days as one of the basic ways to log the player’s and team’s actions (e.g., passes, rebounds, turnovers, recurrent movements). At the end of the matches, those documents are statistically analysed by the technical staff and the players are notified about their actions. The log work is made by someone that is observing the game (live or recorded) and marking those moments by hand. This is a slow process and, in live games, can require more than one person to process all actions with an optimum precision.

This paper shows our alternative to that kind of work. Our system rests on a one camera tracking system: (a) a portable camera that can be placed in the stands to acquire the images; (b) software to process the (live or recorded) matches. The returned data is then used to show individual or team actions. This work deals with the constructions of the heat, passes and loss ball maps for a football match. With this process, the information can be given in real time, allowing an instantaneous analysis of the players and teams actions, which gives the possibility to the technical staff to make in game adjustments, based on that information. As expected, knowing the opposite team performance is also possible with this system, which can give an extra advantage to those using these features. This work is a part of the Footdata project [1].

On the market there are some systems which incorporate partially some of the components of this project, for example, Kizanaro ® [2] Tracab ® [3] Prozone ® [4] Amisco ® [5], and SportVU ® [6]. We can also find some research that explores aspects of the project, such as Spatial and Spatiotemporal Analysis of Soccer [7], and tactical analysis in football, [8], [9] and [10]. Our system, which integrates the tools presented in this paper, will integrate some of the functionalities that these systems already have.

Since one of the main objectives of the Footdata project was to build an operating system (OS) independent software it was decided to make it as a web application, so it can run in all equipment that have a browser (such as, Chrome, Firefox, or Safari) and an internet connection. The web application is being developed with the django framework. You can find more detailed information about the library developed by us in python, so it can be integrated with the web application is being developed with the django framework were all the coding is made in python that has the same size as the image resolution used to draw it.

HM is build using the data from the tracking system, that returns for each frame the players’ and ball’s positions in meters, \([f_{rame \_id} : t, ^{team \_A} : (player_1 : (x_1, y_1), player_2 : (x_2, y_2), \ldots ), \] ^{team \_B} : \ldots , ^{ball} : (x, y)) \]. Those positions are relative to the pitch top left corner and are obtained using an homography [14]. To compute \( H M \) we start by setting it to the null matrix, \( H M = 0 \), then for each frame a cross-multiplication is used to get the corresponding positions of the players in the pitch, \((x, y)\), to their corresponding entry in \( H M \) matrix, \((x', y')\), and \( H M_{x'y'} \) is incremented by one unit. Once all the frames and players are processed, the matrix is normalized, i.e., each entry of the matrix is divided by the matrix maximum element. Finally, the \( H M \) values (ranging from 0 to 1) are used to build the SVG image, by setting the colour opacity of the pixels that form the heat map.

Figure 1 sketches a team heat map from one minute of a football match. The heat map can be filtered within different time intervals, and individual or multiple players (Figure 2).

3 Passes Maps
The passes maps are a graphical representation of the passes made by the players in the game. It shows the passing player’s number and the receiver’s number. The passes map is a tool which allows several analyses, like how a team organises the attack or maintains the ball possession. Other statistics can also be inferred like who are the most important players in the teams’ strategies, in the sense that they have more ball actions.

The following process is operated to find the passes between the players. In each frame, (1) the distance between the players and the ball is calculated; (2) if the ball enters in a player’s radius (empirical tests, revealed good results considering a radius distance equivalent to 1.3 meters), that frame and player are tagged; and the ball velocity and direction are calculated using the current position and its position five frames before; (3) if the ball leaves that player’s radius, the velocity and direction are also calculated, considering the ball’s current position and its position five frames after; (4) the velocity and

Figure 1: Team heat map, from one minute of a football match.

Figure 2: Single player heat map, from one minute of a football match.
direction values are then subjected to a set of conditions (changes in the ball direction or velocity), in order to see if it’s a pass or not: if the ball changes direction or velocity then it is almost sure a pass. The pass detection process is summarized in Algorithm 1. Figures 3 - 4 show a passes map where it’s possible to see all the passes made by both teams, a team or by a single player.

Simultaneously, a log is built as the game is processed, containing a list with the intervening players numbers, teams and time of the pass execution and reception.

### Algorithm 1: Passes Extraction

For each frame

If ball enters player radius

\[ v_i = \text{velocity}(\text{frame}_\text{id}, \text{frame}_\text{id} - 5) \] // ball initial velocity
\[ d_i = \text{direction}(\text{frame}_\text{id}, \text{frame}_\text{id} - 5) \] // ball initial direction

If ball leaves player radius

\[ v_f = \text{velocity}(\text{frame}_\text{id}, \text{frame}_\text{id} + 5) \] // ball final velocity
\[ d_f = \text{direction}(\text{frame}_\text{id}, \text{frame}_\text{id} + 5) \] // ball final direction

If \( d_i \neq d_f \) or \( v_i \neq v_f \)

Almost sure it’s a pass

Else

Not considered as a pass

### 4 Ball Loss Maps

Similar to the passes maps, we have the ball loss maps that can be also filtered by time interval and by player/team (see Figure 5).

Using this map, it’s possible to see which player loses more balls, or in which areas more ball are loss. Analyzing both the passes and loss ball maps, we can have a general view about the player and team performance, by using: heat maps, passes maps and loss ball maps. The maps can be filtered by time intervals, by team or by players, in order to in an easier way understand and evaluate the player’s / team performance. It was also explained our approach in extracting the passes from the information given by the tracking system and how we get the ball losses.

The system is being optimized for football, but the difference between other ball sports is not big, so maybe in a near future our system will be adapted to other sports.

### 5 Conclusion and future work

In this paper we have shown a small part of the overall system that is being built to help coaches and technical staff in the improvement of their players and team’s performance, by using: heat maps, passes maps and loss ball maps. The maps can be filtered by time intervals, by team or by players, in order to in an easier way understand and evaluate the player’s / team performance. It was also explained our approach in extracting the passes from the information given by the tracking system and how we get the ball losses.

The system is being optimized for football, but the difference between other ball sports is not big, so maybe in a near future our system will be adapted to other sports.

### Acknowledgements

This work was supported by FCT project PEst-OE/EEI/LA0009/2013 and project FootData QREN I&DT, n." 23119. We also thanks to project leader Inesting, S.A. [www.inesting.com], and the consultant football coach Domingos Paciência and our colleague Carlos Gomes.

### 6 References


